ON INDIAN PARASITIC FLIES.

BY

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PART III.

With 3 Plates.

(*Continued from page 718 of this Volume.*)

IV.

THE PUPIPARA.

The Pupipara are a remarkable group of flies, with numerous Indian representatives, whose structure has been greatly modified in accordance with their parasitic habits. The Diptera already described are all parasites in the larval stage. In the Pupipara the adult perfect flies are parasites which feed upon the blood of their hosts. All the species of the three families, *Hippoboscidæ*, *Nycteribiidæ* and *Streblidæ*, are ectoparasites of warm-blooded vertebrates. They cling persistently to their hosts and seek to crawl in between the hairs or feathers. They are small to moderately large flies. Some forms are winged, others wingless. The winged forms rarely fly long distances, but use these organs of locomotion to pass from one part of the host's body to another, or occasionally, to fly from one host to another in the neighbourhood. The wings may be well developed, rudimentary or entirely wanting. In some species, though the wings may at first be well developed, they are subsequently shed, the insect, on reaching a host, having no further use for them.

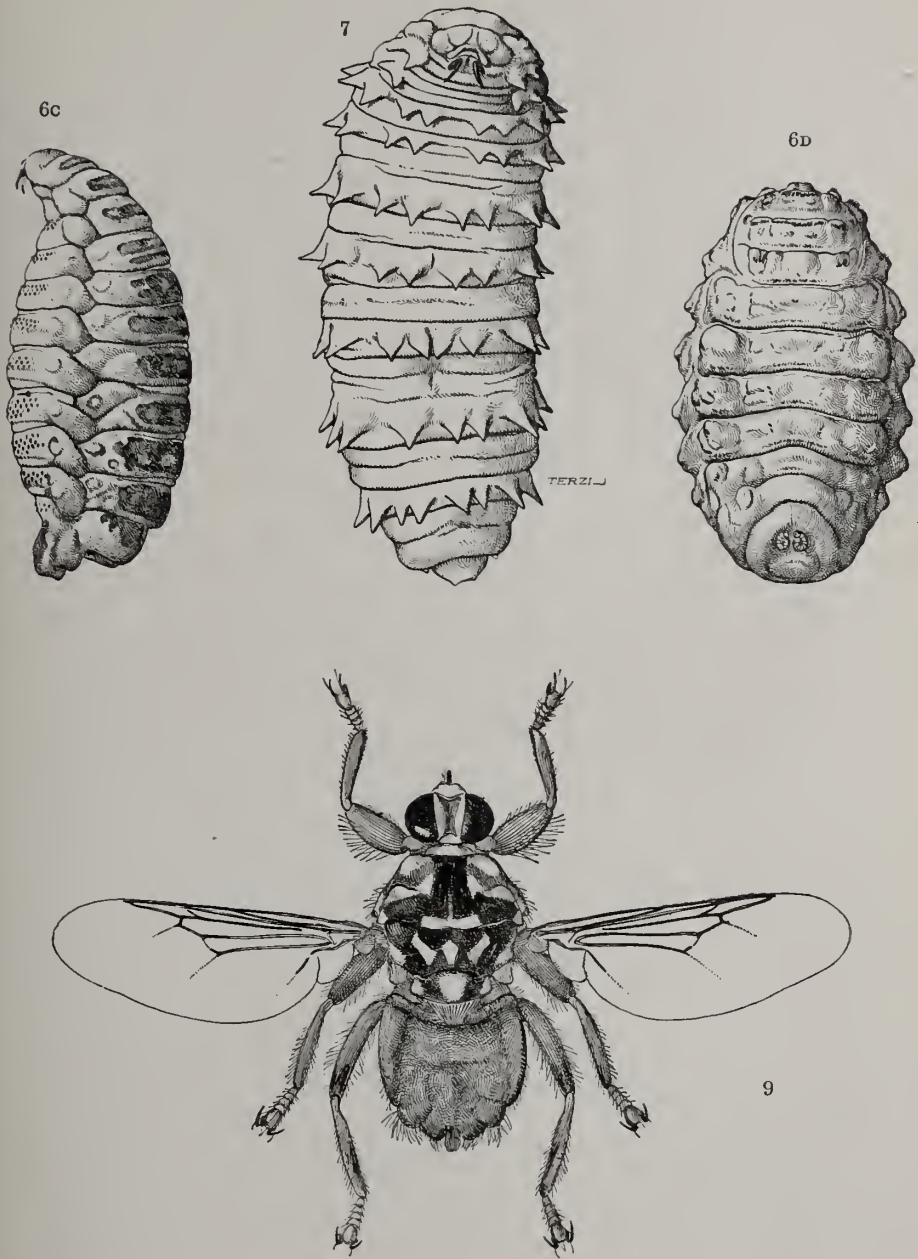
The legs, on the other hand, as might be excepted in parasitic insects, are highly developed. They may be either short, strong and stout, as in Hippoboscids, or, on the other hand, as in the Nycteribiids, which are bat parasites, long, prehensile and slender. The claws are always adapted for clinging to the host and in some forms are toothed and provided with necessary spurs. The body is usually more or less dorso-ventrally compressed, which is another modification frequently found in parasitic insects. As a rule the segmentation of the abdomen is indistinct and its integument is of a leathery consistence. Some forms also are furnished with combs, or rows of spines, which are also organs associated with a parasitic life on mammals or birds.

The name *Pupipara* is really a misnomer, but it is a recognised name and long established. The eggs hatch in the body of the female fly. The larvæ are retained within the maternal body and are there nourished by special glands. When fully mature and ready to pupate they are deposited on the ground or in the abodes and nests of their hosts. Only one larva is produced at a time and on leaving the body

of the mother it pupates. From what has been said it will be seen that the flies included in this group have developed most remarkable modifications and adaptations in connection with their parasitic habits. It is instructive to trace the stages in which the pupiparous habit has been developed. The word *pupiparous* is inaccurate because it is not a pupa which is produced from the mature female, but a full grown larva which may pass into the pupal stage on the spot where it is deposited by the mother, or may be capable of moving about until it finds a suitable place for pupation.

The pupiparous habit occurs in three distinct degrees in the Diptera. (*a*) It will be remembered that some Calyptrate Muscoids are viviparous. The eggs are retained within the maternal body until after they have developed into larvæ. The larvæ are very small and are born almost as soon as they hatch out of the egg. They are laid in a large batch, exactly as the eggs of most flies are laid, and undergo little or no development within the body of the mother. This habit probably originates from the circumstances under which the larval stage is passed. Some Tachinid flies, it will be remembered, deposit their young larvæ just hatched from the eggs, in the bodies of other larvæ on which they are parasitic. It is therefore of extreme importance, for their welfare and perhaps their existence, to reduce the duration of the immature stage so that it may be accomplished within a given time. The food supply will fail unless the larval stage of the parasite is completed before the host pupates. (*b*) The second degree occurs in certain Muscid species which are blood-suckers. There the larva on hatching is retained and nourished for part of its life within the body of the mother. But it is deposited before attaining maturity and completes its growth, feeding itself in the same fashion as the normal larvæ of the *Muscidæ*. (*c*) The third degree is found in the Diptera Pupipara where the larva is retained until it is ready to pupate. This involves remarkable changes in the internal structure of the female fly. The large size of the larva during the later stages of its growth renders it necessary that the internal organs of the mother should be greatly modified. More remarkable still is the development of "milk glands" to provide nourishment for the growing larva. The similar pupiparous habits which are found in the Muscid genus *Glossina* (the blood-sucking African Tse-tse flies) emphasize the close connection between the *Muscidæ* and *Hippoboscidæ*.

Hippoboscidæ. This family is probably familiar to Anglo-Indians, who are at all observant in matters of entomology, for the flies are common parasites of cattle and dogs. They are commonly known as "cattle-flies" or "dog-flies" and also as "skaters" and Kukumacchi. The native cattle do not seem to be much troubled by their presence or blood-sucking propensities, but dogs of British breed are worried to distraction.



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INDIAN PARASITIC FLIES.

6C.—Larva of *Œstrus ovis*, L. x 4.
6D.—Larva of *Hypoderma bovis*, de Geer. x 2½.
7.—Larva of *Cephalomyia maculata*, Wied. x 3.
9.—*Hippobosca maculata*, Leach, ♀. x 6.

The greatest European authority on this family is Dr. Paul Speiser, a Prussian doctor of medicine and an entomologist, whose writings and researches during the last twenty years have added greatly to our knowledge.* The family has a world-wide distribution and somewhere about a hundred species have been discovered and described. Speiser has recognised five sub-families ; but as one of these is confined to Madagascar where lemurs are their hosts it need not trouble us further. There occur in India representatives of the four other sub-families : *Hippoboscinæ*, *Lipopteninæ*, *Olfersiinæ*, *Ornithomyiinæ*. Until the family received attention from Speiser it had been much neglected. The Indian species are hardly known and the list in the late F. M. Van der Wulp's "Catalogue of the Described Diptera from South Asia" (1896) might be greatly added to. For instance, the British Museum collection contains specimens of the horse parasite *Hippobosca equina* L., a male from Upper Burmah and a female from Bengal ; also the camel parasite *H. camelina*, Leach, a single female from South Afghanistan. Even *H. maculata*, Leach, one of the commonest Indian species is omitted from Van der Wulp's Catalogue. The British Museum has a good series from various localities in India and Ceylon.†

The Hippoboscids are flat and leathery looking flies with a short proboscis designed for blood-sucking and capable of protrusion when in use, but protected by the palpi when the insect is crawling among hair or feathers. The tip is furnished with sharp chitinous teeth to pierce the skin of the host. They are all blood-suckers and all parasites which spend more or less of their lives on the bodies of their hosts. The parasitism is reflected in the development of strong legs with powerful claws and small inconspicuous antennæ. The associated blood-sucking habit has led to the usual Dipterous life-history becoming reversed. In the present group the blood-sucking habit enables the adult female to supply nourishment of the richest description to carry on the life of the larva within her own body and the larva is born when about to pupate. The puparium looks like a brown shiny seed with a dark cap at one end. When first laid it is soft and white like a larva, which in fact it is. The mahogany colour and hard outer skin are assumed in a few days. These puparia may be found in dry places, on shelves or stone floors in cattle-sheds and stables. Where the hosts have nests, the larvæ are dropped in

*Dr. Speiser's chief papers are the following which should be referred to by anyone who knows German. They contain many suggestive remarks on parasitic Diptera : (1902) "Studien uber Diptera pupipara." Zeits. fiir syst. Hymenopterologi- und Dipterologie Vol. II. p. 145. (1905) "Beitrage zur Kenntniss der Hippoboscicden." Idem Vol. V. p. 347. (1908) "Die Geographische Verbreitung der Diptera pupipari und thre Phylogenie." Zeits. fiir wiss. Insektenbiologie. Vol. IV pp. 241, 301, 420, 437.

† Notes on Hippoboscidae in the British Museum. By E. E. Austen, Ann. and Mag. of Nat. Hist. 7th Series, 1903. Vol. XII. p. 255.

the nests and there pupate. The larva does not feed and only one is produced at a birth; but as the Hippoboscids have spread over the globe, and in some countries are relatively abundant, one must assume that the slow birth-rate is compensated for by the avoidance of manifold dangers which assail larval life.

Most Hippoboscids have no distinct neck and the head is sunk deep in the thorax, so as to be protected when working a way over the host's body. The wings of Hippoboscids are an interesting subject of study. In connection with the sedentary life, which parasitism tends to produce, there is a progressive reduction of the wings until in the genus *Melophagus*, which is a sheep parasite, wings are always entirely absent. These are wingless flies incapable of flight which pass the whole of their existence on their hosts and which can only get to a new host when the two sheep are touching or in close proximity. In the sub-family *Hippoboscinæ* the wings are well developed. In the *Lipopteninæ* the wings are very weak and often practically useless. In some species, which are parasites of deer, male and female flies emerge from the pupal stage with wings which they use to reach a host. Those of the female at once break off leaving a pair of stumps; or it may be that she rids herself of organs which are of no more use. Once in the coat of the deer she has conquered the problem of nourishment. The problem of reproduction involves a visit from a male fly. The males appear to retain their wings longer, possibly until they have found a deer with female parasites. Later in the season both sexes cohabit in a wingless condition as parasites in the hairs of the host. *Lipoptena moschi* is a parasite of the musk-deer. *L. gracilis* has been obtained in India from chevrotains. *L. pteropi* occurs in Ceylon on fruit eating bats.

In the *Olfersiinæ* the wings are well developed whilst in the *Ornithomyiinæ* they are often fairly substantial. In some cases they are reduced to mere rags or shreds. Now both these sub-families are typically bird parasites. *Lynchia exornata* Sp., which occurs frequently on pigeons in India, is a member of the first named group. It would seem that the wings are retained by the bird parasites as a useful adjunct in connection with winged hosts. When a bird infested by these flies is shot, one or more flies will often follow the sportsman who carries the dead host, sometimes alighting on him and seeking refuge in his hair, beard or clothing.

But even in the winged Hippoboscids there are signs of incipient atrophy of the wings which must be attributed to the effects of parasitic habits. The veins are crowded together along the anterior wing-border, whilst the few veins which run obliquely across the wing are lacking in strength.

Some account of the life-history and structure of *Hippobosca maculata*, a well-known Indian cattle fly, will serve to illustrate the

adaptations which have been developed by this family in connection with their parasitic habits. On emerging from the pupal stage the insect, when its wings and body have hardened in the air, must seek a host on whose blood it will feed and on whose body it will dwell. For this purpose the wings are used ; but once established on the cattle these flies rarely use their wings except to move from one part of the host's body to another or to fly a short distance to another member of the herd. They cling in clusters to the softer parts of the body between the legs and beneath the tail. They move slowly and laboriously, often side-ways with crab-like motion. So far as is known the female deposits her single larva on the ground in places frequented by cattle. The larva is incapable of movement, and forthwith pupates, whilst the mother returns to the host to suck more blood and nourish another single larva. How many larvæ are thus successively produced is unknown, but probably they are comparatively few in number. This is one of the contrasts between this present family and other usually prolific Diptera. The ovaries are greatly modified. A single large egg is produced at a time and the larva remains in the distended oviduct. After extrusion the larva hardens by the excretion of chitin and it then resembles a small brown pea. Out of this emerges in due course another generation. There is no free larval life. Such is the cycle of life in *H. maculata*.

The structure of *H. maculata* is typical of many other members of the family. The flies are of middle size with oval flattened bodies of a tough and coriaceous texture. This is an adaptation which enables the parasite to apply itself closely to the host's body and to stand with impunity a certain amount of violence if the host tries to dislodge it. The head is small and not half the breadth of the thorax. The fly has a pair of large, oblong, compound eyes, but they are not prominent and the facets are notably small. There are no ocelli in this species, but some other Hippoboscids have simple eyes as well as the compound ones. The antennæ are extremely short. The first and second joints are indistinct while the third joint is round and bears a bristle-like arista. The thorax is broad. The abdomen is slightly hairy, compact and leathery so that the sutures between the segments are indistinct. The sexes can be readily distinguished by the shape of the abdomen which in the male is linear, shorter and narrower than the thorax ; in the female it is oval, longer and broader than the thorax.

We come now to the legs and wings which show modifications connected with a parasitic and sedentary life. The legs are rather short, very stout and slightly bristly. The two posterior pairs are fixed wide apart. The tibiæ are a little shorter than the femora ; the tarsi are half the length of the tibiæ. Each foot terminates with ungues or claws which are long, stout, curved and bidentate. The

legs in fact have become modified so as to form organs for clinging rather than for locomotion.

The wings, on the other hand, are less strong than the normal Dipterous type. The costal vein extends about three quarters of the length of the wing and the sub-costal only half the length. Along the anterior margin of the wing there are a number of veins in close proximity, but the posterior part of the wing is weak and reduced. There are no veins to support and strengthen the membrane. When the wings are closed they are crossed like a pair of scissors and cover or conceal the abdomen of the fly.* The wings in fact are becoming atrophied as organs of locomotion.

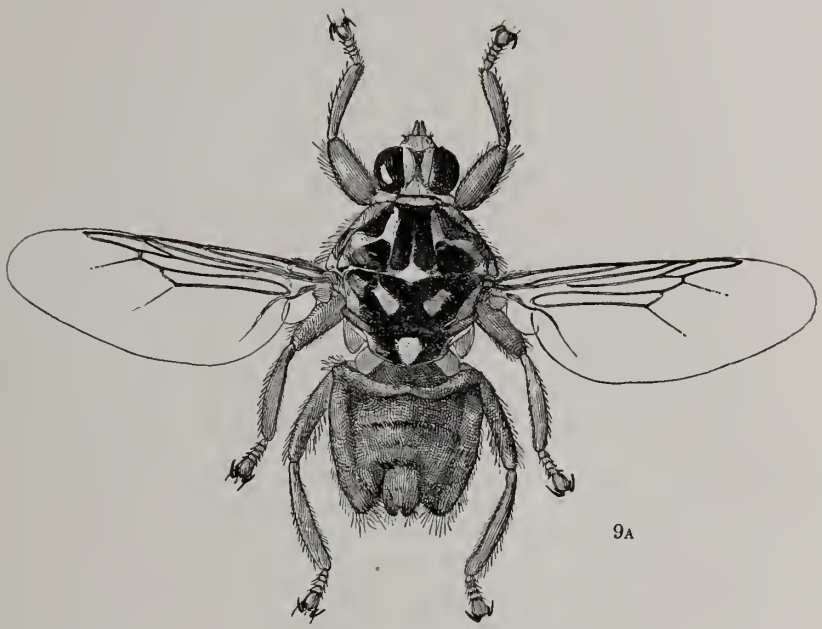
The general colouring of these flies is brown, mottled, with yellow on the thorax and legs. They are found on horses, occasionally, as well as on cattle ; but they can be distinguished from *H. equina* L. which is essentially a parasite of horses. *H. maculata* is an Indian or South Asiatic species. It was introduced into Madagascar with Indian cattle. During the Boer War it was introduced into South Africa in the same way and is apparently established there.

The travels of these parasitic flies in company with their hosts are illustrated in the case of *H. capensis* well-known in India and Ceylon as a pest of dogs. It is a fly of hot countries with habits somewhat similar to the last mentioned species. It is now found on the shores of the Mediterranean and down the East African coast as far as the Cape. There it has long extended its range into the interior. From Africa it also ranges eastward across Southern Asia as far as Korea and Japan. Such a geographical distribution can only be explained by man's action. We do not know the original habitat of this dog parasite, but it has evidently accompanied the friend of man in its travels with its master.

The Indian Hippoboscids which are found on birds are very imperfectly known but there must certainly be numerous species belonging to the two sub-families *Ornithomyiinæ* and *Olfersiinæ*. All forms of birds appear to be victimised and the parasites of the birds seem to be less particular as to their host than those which attach themselves to mammals. The same fly has been collected from widely different birds. The parasites migrate naturally with their hosts and certain species of these flies such as *Ornithomyia avicularia* L. are found almost all over the globe on all sorts of birds. On the other hand one genus of fly (*Stenopteryx*) is associated with the swallow-family and another (*Oxypterum*) with the swift-family. Why this should be we do not know at present, but may some day discover.

Streblidæ. The flies of this small and little known family are for the most part ecto-parasites of bats. One Central American species

* The reader will find a good coloured figure of *H. maculata* in " Indian Insect Life " by H. Maxwell-Lefroy, Calcutta, 1909 (Plate LXIX. fig. 7.) which will enable the above description to be followed.



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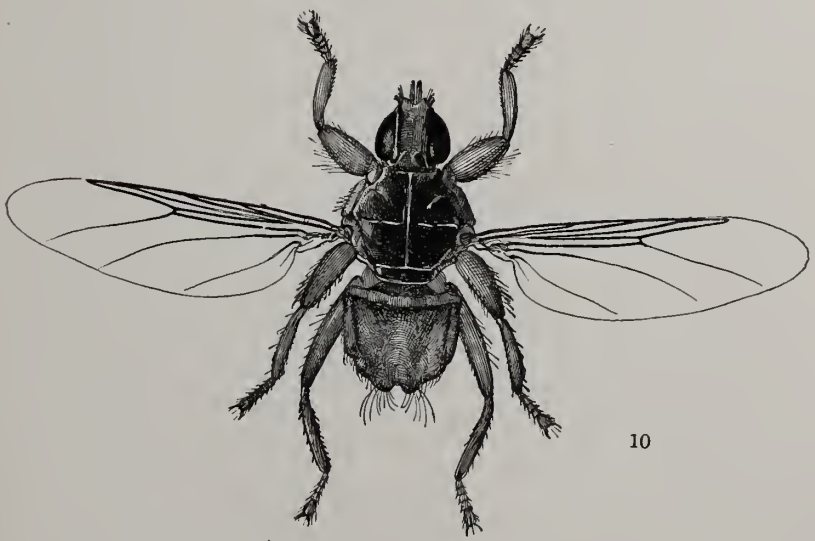

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INDIAN PARASITIC FLIES.

9A.—*Hippobosca camelina*, Leach, ♀. x 5.
10.—*Lynchia maura*, Bigot, ♀. x 6.

is a bird parasite. They were separated from the *Hippoboscidæ* by Kolenati (1862) and seem to form a natural group between that family and the *Nycteribiidæ* which are more highly specialised and exclusively bat-parasites. They are, however, nearer the Hippoboscids and are probably descended likewise from Muscid ancestors but along another line of descent. Some are destitute of eyes; and where eyes are present the Streblids may usually be distinguished from the Hippoboscids by two fairly salient features. First, no Streblids have facetted compound eyes. Where the eyes are more than single ocelli they are formed by the agglomeration of several occelli. Secondly, in the Streblids the palpi do not sheathe the proboscis as they do in the Hippoboscids.

A Streblid fly can often be recognised at a glance by the flattened leaflike pair of maxillary palpi which project in front of the head. Kolenati was certainly wrong when he suggested that the larval Streblids fed on the excrement of the bats; they are pupiparous and their methods of reproduction are similar to those of the other families in that group. In some forms the legs are short and thick recalling those of the Hippoboscids; in others they are enormously long and attenuated, or spider-like, recalling those of the Nycteribiids. It is of interest to note, in this connection, the two contrary lines along which the legs of ectoparasitic Diptera have evolved from the normal type in flies, the object in both cases, of course, being to secure a hold on the host. Wings in Streblids are sometimes well developed, sometimes reduced and sometimes absent. They are never much used as organs of locomotion; and, where wings are well developed, they are covered with fine hairs which give a milky appearance rather unusual among flies. Where the wings are reduced, the wing venation is unlike that of the Hippoboscid wing, showing that reduction in this family has proceeded on other lines. Halteres are present but in the wingless species they are reduced. In many species of Streblid the halteres are protected by a projection of the thorax which may be regarded as an adaptation developed in connection with parasitic life to shield these delicate organs when the fly makes its way about the body of the host. The claws are always well developed; and in one species, which is quite wingless, there is an indication of an accessory tooth. This is another illustration of the tendency among parasites to develop organs of prehension when organs of locomotion are lost.

The abdomen in this family shows little sign of segmentation except at the base where it is united to the thorax. In the winged species, the wings are contrived to fold back fan-wise and lie flat upon the surface of the insect's back. With this, the arrangement of bristles on the dorsal surface of the abdomen seems to coincide; for there is a bare tract along the back where the wings are tucked away. On

either side a row of stout bristles, with a pair of chitinous hooks on the first abdominal segment, shield them from injury when the insect is creeping through the hairs of its host. Some have also a row of stout bristles or spines arranged across the ventral surface of the abdomen which reminds one forcibly of the abdominal ctenidium in the Nycteribiids and which probably serves a similar purpose.

In the genus *Strebla*, Wied, from which the family is named there are at least four peculiarities which have been developed as parasitic adjuncts. First, there is a collar of many chitinous spines beneath the head which seems to be analogous with the ctenidium of Nycteribiids; secondly, there is a collar with a few similar spines on the dorsal surface at the back of the head; thirdly, on the surface of the head and directed forwards, there is a semi-circular plate with seven rows of spines below and two large ones above all directed backwards so as to facilitate progress forwards; fourthly, there are two grooves along the sides of the thorax which enable the very long pair of front legs to be tucked away when the parasite requires to protect them. The grooves are fringed along the margin with spines and are shaped to contain the tibial joint when the legs are folded. The front pair of legs are placed far in front of the middle and hind pair and are separated from them by nearly the whole length of the thorax. These extremely strange peculiarities in the insects' morphology are difficult to make intelligible to the reader by a mere verbal description. They are, however, clearly seen in the two well drawn and large plates at the end of Dr. Speiser's paper which contains the best general account of the flies of this family that has yet been written.*

Among certain Streblids of the genus *Ascodipteron* there is an extraordinary divergence between the male and female, both as regards appearance and life history. These insects are found in the Oriental region and may some day be obtained in India. The first member of this remarkable group was discovered in 1896 by Dr. Theodor Adensamer of Vienna who found a solitary specimen embedded in the wing-membrane of a bat which he had brought back from Java.† Dissection of the internal organs under the microscope showed it to be a female Dipteron reduced by parasitism to a shapeless lump. He rightly guessed that when the males were discovered they would prove to be free-living normal insects. We now know that the female is at first winged but imbeds herself in the bat, sheds her wings and legs and undergoes post-imaginal metamorphosis into a flask-shaped object. Her abdomen grows to such an extent that it surrounds and

* "Ueber die Strebliden, Fledermaus Parasiten aus der Gruppe der pupiparen Dipteren" by P. Speiser (1900) Archiv für Naturg. 66 Jahrg. Vol. I. p. 31. 2 Plates and Bibliography.

† T. Adensamer: "Uber *Ascodipteron phyllorinae* (n. gen. n. sp.) eine eigenthümliche Pupiparenform". (1896). Sitzungsb. K. Akad. der Wissenschaft. Wien, Vol. 105. Pt. I. p.400. 2 Plates.

covers her head and thorax. The proboscis of the female is modified to enable her to cut into the skin of the host but the homology with the normal Streblid proboscis can be discerned. The following summary is based on the observations made by Mr. F. Muir, an American entomologist.* The adult flies emerge from the pupa-case which lies upon the ground in caves and other haunts of bats. Both sexes are perfectly normal flies with fully developed legs and wings. They are of a light reddish-brown colour with a pair of large rounded wings. Both sexes are destitute of eyes and only the male has maxillary palps or feelers. The most striking features in the female is the enormous size of the proboscis and the fact that head and thorax appear as though welded into one piece. But for this she has the normal appearance of a small fly and nothing suggests how she will end her days. The proboscis is a chitinous, broad, flattened, blunt cone with a base somewhat wider than the head. At the apex of the proboscis there arise fourteen rows of chitinous blades. They are like circular saws cut in half so as to form a row of semi-circles placed side by side.

There is a short gap in our knowledge of the life history but the pairing of the sexes probably takes place in a normal manner whilst the female is winged. The female then seeks her host and by theaid of the blades at the end of her proboscis cuts through the skin of the bat. The parasites were always found imbedded in the same position under the skin at the base of the ear. There were usually two, rarely three, but sometimes only one specimen on a bat. When she is imbedded the abdomen enlarges and engulfs the head and thorax so that eventually they lie at the bottom of a pit at the anterior end of the abdomen. The fly burrows into the bat head foremost and the posterior end of the abdomen remains protruding. The presence of the parasite makes itself visible as a swelling with a small pearly-white body protruding at one side thereof. When cut out of the host the parasite appears as a semitranslucent white flask-shaped body four to five millimetres long. No head or thorax is visible. Wings and legs are gone. How and when the female gets rid of them remains a mystery. The stumps can be detected but there are no traces of legs or wings in the cavity formed under the skin of the bat. The proboscis is so rigidly fixed to the head that it could not be used to sever wings or legs. They must, by some other means, be got rid of before the female insect is completely imbedded. In this dismal fashion she produces her larvæ which are born mature, fall to the ground and pupate at once. The male fly is not provided with adequate weapons on his proboscis to cut through the skin of a bat. He

* Muir found that at Amboina only one species of bat (*Miniopterus schreibersi*) was attacked by *Ascodipteron speiserianum* and that 28 per cent of the bats examined were infested. F. Muir: Two new species of Ascodipteron. (1912) Bull. Mus. Zool. Harvard, Vol. LIV. pp. 351-366. 3 Plates.

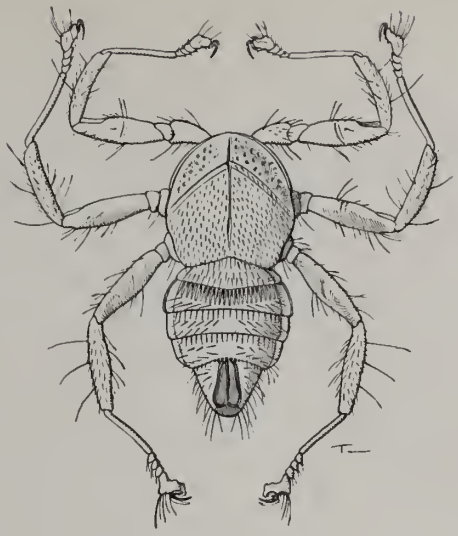
remains external, enjoying a free and, let us hope, merrier life. He is a normal pupiparous fly in habits, structure and development similar to other Streblids. The reader who is an entomologist will at once think of an analogous case where the female of a parasitic insect buries herself in the flesh of the host, namely the jigger flea, *Dermatophilus*, of hot countries.

The distribution of the Streblids is not at all accurately known. *Nycteribosca gigantea*, Speis., has been taken off bats in the caves of Burmah. Two species of *Raymondia*, Frfld., have been collected in Madras. There must be numerous species in India if they were searched for, since bat parasites have been so little collected.

Nycteribiidæ. The members of this family are wingless flies parasitic on bats ; and it follows that the ordinary person who does not make a special business of collecting bat-parasites is unlikely ever to come across them. The family is an extremely interesting one because of the extraordinary morphological modifications which the typical Dipterous structure has undergone under the influence of a highly specialised parasitic existence. These insects pass almost the whole of their lives on the bat's body and derive the whole of their nourishment from its blood which they suck at frequent intervals. The Swedish naturalist, Linnæus (1758), thought that they were lice. Latreille (1795) established the genus *Nycteribia*. This eminent French entomologist also saw that these insects were, in fact, wingless flies and not lice. The ordinary unlearned person might mistake them for small spiders, which they somewhat resemble both in form and in manner of movement.

The *Nycteribiidæ* have an almost world-wide distribution. Bats are found all over the globe except in the Polar regions. It would seem that all sorts of bats are at times infested with these parasites. An individual bat may harbour Nycteribiids belonging to two different genera ; and several species of these insects have frequently been taken from the same species of bat. The migratory powers of the hosts are sufficient to explain the wide geographical distribution of these parasites. Nine different species of Nycteribiid have been collected from one form of bat which has an exceptionally wide geographical range. It is a well established generalisation that these bat parasites have their headquarters in the Old World and are most abundant in the countries which lie round the Indian Ocean. Speiser, who is again the greatest authority on the family, recognises some eight genera and between thirty and forty species.* The genus *Archi-*

* In his learned and painstaking paper there will be found a full bibliography of the literature down to 1901 and a summary of our knowledge of the group together with a revision of the family and a table to show the geographical distribution. See "Ueber die Nycteribiiden, Fledermaus Parasiten aus der Gruppe der pupiparen Dipteren." Von cand. med. P. Speiser. *Archiv fur Naturgeschichte* (1901) 66th yea Vol. I. p. 11.



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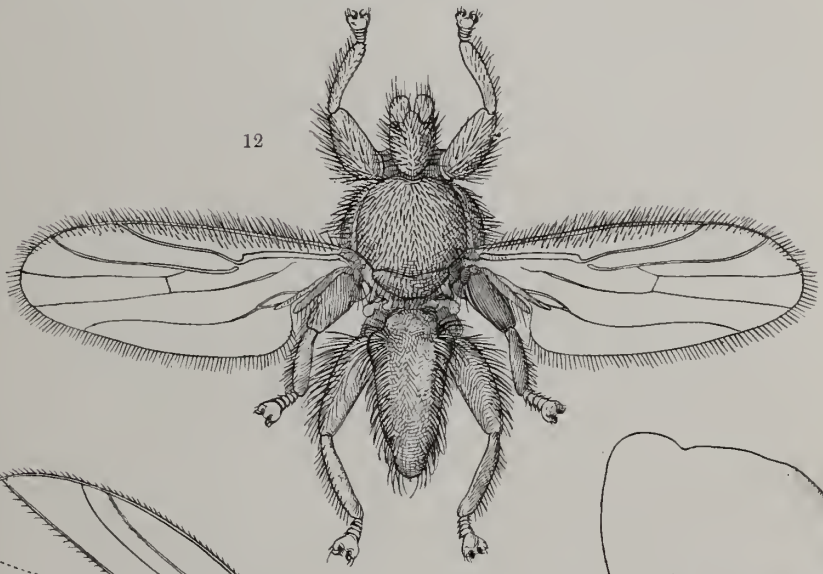

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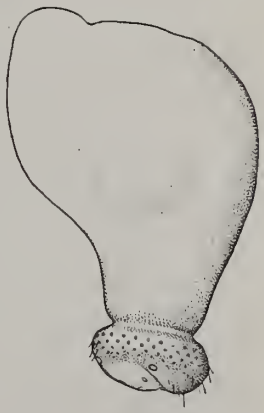

13A

INDIAN PARASITIC FLIES.

11.—*Nycteribia* sp. (after Sharp.) x 9.

12.—*Nycteribosca amboinensis*, Rondani. (From Biserat, Malay Peninsula.) x 22.

13.—*Ascodipteron speiserianum*, Muir ♀. (After Muir.) x 25.

13A.—*Ascodipteron phyllorhinæ*, Adensamer ♀. (After Adensamer.) x 10.

nycteribia with a single species from New Guinea may represent an ancestral type : the first tarsal segment of the legs instead of being long and attenuated is exceedingly short and hardly so long as the three next segments put together ; there is no ctenidium or comb on the underside of the abdomen.

No mere description can give more than a general view of the comformation of these remarkable Diptera.* There are no vestiges whatever of the front pair of wings but all species have halteres representing the second pair of wings. The retention of these stalked knobs in a group which does not fly is some confirmation of the belief that the halteres are not balancers but sense-organs. The separation of head, thorax and abdomen is clearly marked. The head is small and attached to the upper side of the thorax by such a slender and flexible neck that in dead specimens the head is often completely bent back. In such cases the back of the head rests on the thorax and the mouth parts are directed upwards to the heavens. It was at one time thought that Nycteribiids must turn over to feed but it seems uncertain whether this unusual posture of the head is ever adopted when the insect is alive.

The conformation of the thorax and position of the legs is also singular. The lower surface is strongly protected with a dark and horny chitin whilst the upper surface is soft and of a yellowish white. It is just the reverse of what one finds in other Diptera. The ventral plate of the thorax projects in front under the head and to the rear beyond where the abdomen is rooted to the thorax. But the oddity does not rest there, for the three pairs of legs are inserted on the upper instead of the nether surface of the thorax. In fact the ventral plate is prolonged round the sides of the thorax. In death the six legs are contracted together over the back instead of under the belly as in a dead house-fly. In life the insects seem to be running about upside down or with belly uppermost. Although their native heath is the furry skin of a bat, they can make good progress on a mahogany table.

The six legs of a Nycteribiid conform in general, as to structure, with those of other Diptera and all the normal segments are present : coxa, trochanter, femur, tibia, tarsus. The following peculiarities are note-worthy. First in every species of Nycteribiid the femur is marked with a ring or furrow of lighter coloured and softer chitin which would seem to increase the flexibility and reduce the rigidity of the segment ; secondly, in two genera both of which are Indian (*Cyclopodia* and *Eucampsipoda*) the tibiæ are similarly marked respectively with two or three rings, as the case may be, which make the tibial segments more lissom ; thirdly, the tarsi have peculiarities

* There is an excellent figure of a Nycteribiid in the Cambridge Natural History "*Insects*" and also in Mr. Hugh Scott's paper on these insects *Parasitology* (1917) Vol. IX. p. 593. The coloured figure in *Indian Insect Life* by H. Maxwell Lefroy, Plate LXIX, is too small to show the structure in detail.

which are almost unique among insects. The tarsi are five-jointed and the distal joint is furnished with a pair of curved claws like grappling irons. The first tarsal segment is of immense length, very slender and occasionally bowed. It is capable of being twisted in every direction and in some species is actually longer than the tibia which is next to it. The result is to increase the prehensile power of the parasites when the bats move and to enable them to adjust their hold to any contortions of the hosts.

The abdomen is the bulkiest portion of the insect's body. That of the male is darker and more chitinous ; that of the female is soft, membranous and capable of distention. Both sexes have numerous bristles on the abdomen directed backwards and systematically arranged so as to be of some taxonomic importance. The total length of the body is from one to four millimetres. The largest species are parasitic on tropical fruit-bats. The majority of species are provided with ctenidia or combs such as are familiar to students of fleas and some other insects parasitic on mammals or birds. The combs are furnished with horny teeth and facilitate progress through or over the fur of the host. They may also serve to protect the joints of the parasite against the hairs of the host. All Nycteribiids (except the genus *Eremoctenia* which has no combs at all) have a pair of combs attached to the thorax in front of the insertion of the first pair of legs. Associated with the comb is a groove from which apparently it can be raised, or into which it can be depressed by special muscles, as occasion may require. The thoracic combs may have from 9 to 22 teeth. They are not, as was once thought, atrophied vestiges of a pair of wings but distinct organs evolved in connection with parasitic life. All Nycteribiids (except the two genera *Eremoctenia* and *Archinycteribia*) have a comb on the underside of the abdomen attached to the second segment. There are seven segments but the first is almost invisible.

Speiser in the paper alluded to above gives the following thirteen species as having been obtained in the Indian region where the Nycteribiids are represented by more species than in other geographical regions. Our knowledge is too scanty to lay down in detail the geographical distribution of the various forms.

Indian Region.

1. *Penicillidia ienynsi* (Westw.)
2. *P. cuxesta*, Sp.
3. *Nycteribia minuta*, v. d. W.
4. *N. stichotricha*, Sp.
5. *N. roylei*. Westw.
6. *N. parvula*. Sp.
7. *N. allotopa*, Sp.
8. *Cyclopodia albertisi*, Rnd.
9. *C. horsfieldi*, de Meij.
10. *C. sykesi* (×Westw.)
11. *C. hopei* (Westw.)
12. *C. ferrarii* (Rnd.)
13. *Eucampsipoda hyrtli* (Kol.)

There remain some further facts worth noting on the habits and structure of these dipterous parasites. Many species are destitute of eyes, and where ocelli are present, they are of such a simple kind that the insects' power of vision must be of the poorest description. The antennæ are only two-jointed and are protected by deep pits at the base of which they are inserted. On the under side of the head there is a narrow groove into which fit proboscis and maxillary palpi. All these characteristics are features frequently found in many ecto-parasitic insects. With them may be also mentioned prehensile legs with clawed feet, ctenidia or combs, and the absence of wings.

The pupiparous habit of the Nycteribiids was made known by J. O. Westwood (1835) and some recent observations on this have been made by keeping fruit-bats in captivity and watching the doings of their parasites. When the time for her labour arrived, the female insect hurriedly left the bats and sought a suitable place to deposit her larva. Under natural conditions this would be some part of the tree where these bats congregate. The larva is a minute soft yellowish-white maggot of oval shape and dorso-ventrally compressed. It does not move and is covered with a sticky substance. Immedately after parturition the female stood over the larva and pressed it down with her thorax, causing it to adhere to the place where it was laid. She then hastened back to the bat. The males were never seen to leave the bats but they doubtless travel in search of females. In some species the female Nycteribiid fastens her larva to the host by means of the adhesive exudation. The place generally chosen is near the junction of the wing-membrane and the bat's body. The larva a once assumes the shape of a puparium ; in half an hour it has hardened and darkened ; in 48 hours the transformation into a pupa is complete. The pupal stage lasts about a fortnight. For those species which deposit their larvæ in the haunts of their hosts and not on their bodies this is a critical moment. The perfect insect must secure a host or it will perish in about forty-eight hours. A newly emerged female *Cyclopodia* has been observed to begin to breed in about ten days. Ten larvæ were produced in twenty-nine days. For a fly this is not prolific and one may infer that mortality from failure to secure a host is not heavy. A high birth rate is not always a sign of prosperity nor of high evolution either in the vertebrate or the arthropod world.